DG press

service & innovation for you

An Introduction to Web Offset Printing

for Packaging and Labels

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The Basics

1. Offset printing: What is it and how does it work?

The term "offset" refers to a printing technique where the ink for the image is transferred indirectly from the image carrier, the offset plate, over a printing blanket onto the printable substrate.

Offset in general is still the most widely used printing process globally. This includes cold-set for newspaper printing, heat-set printing for magazines and sheet-fed printing for brochures, calendars, magazines, cardboard and more. Advantages like the highest print quality, inexpensive printing plates and fast prepress are some of the key advantages of offset printing over other printing technologies.

Web offset printing is one form of offset printing where the printed substrate passes as a continuous web through the offset press. In web offset the substrate is unwound from a reel and in most cases, like for flexible packaging and labels, is rewound after printing, as further processing like packaging and labelling can only handle web-shaped substrates.

Besides the handling of the substrate in web- or sheet-fed offset, there are three different forms of offset printing depending on the type of offset plate that is used. The three forms of offset are wet offset, also known as lithography, dry offset and waterless offset. Of these embodiments, wet offset is the most widespread and commonly used offset printing technique.

Wet offset is also the main printing technology used in the printing machines from DG press for printing flexible packaging and labels. The ins and outs of wet offset will be explained more in-depth in this guide. The other two technologies, dry offset and waterless offset are not covered in this guide.

The functioning principle of wet offset printing is based on the mutual repulsion of oil and water. The image areas of an offset plate are polymeric and ink-friendly while the non-images areas are aluminium oxide and extremely hydrophilic, or water friendly. The tiny water layer on the non-image areas makes those areas ink-repellent, in this way keeping the non-image areas free from ink.

Offset printing units exist in two embodiments. The first is named blanket-to-impression cylinder which is used for single-side printing and the second is blanket-to-blanket cylinder which is used for simultaneous two-side printing The first one, the blanket-to-impression cylinder, is the most common and can be found in web offset presses for packaging and labels and in almost all sheet-fed presses. The second one, blanket-to-blanket, is typical for heat-set presses and newspaper presses. The blanket-to-blanket technology plays no role in packaging, labels, security, cardboard or pharma and therefore this type will not be given any further explanation in this guide.

Offset printing units of the blanket-to-impression cylinder type consist of 3 printing cylinders:

- The plate cylinder that holds the offset plate with the image. It receives the ink/water emulsion from the roller train and transfers it onto the blanket on the blanket cylinder.
- The blanket cylinder that holds the printing blanket. The blanket receives the ink from the plate and transfers it onto the substrate.
- The impression cylinder pushes the substrate into contact with the blanket cylinder, transferring ink from the blanket to the substrate.

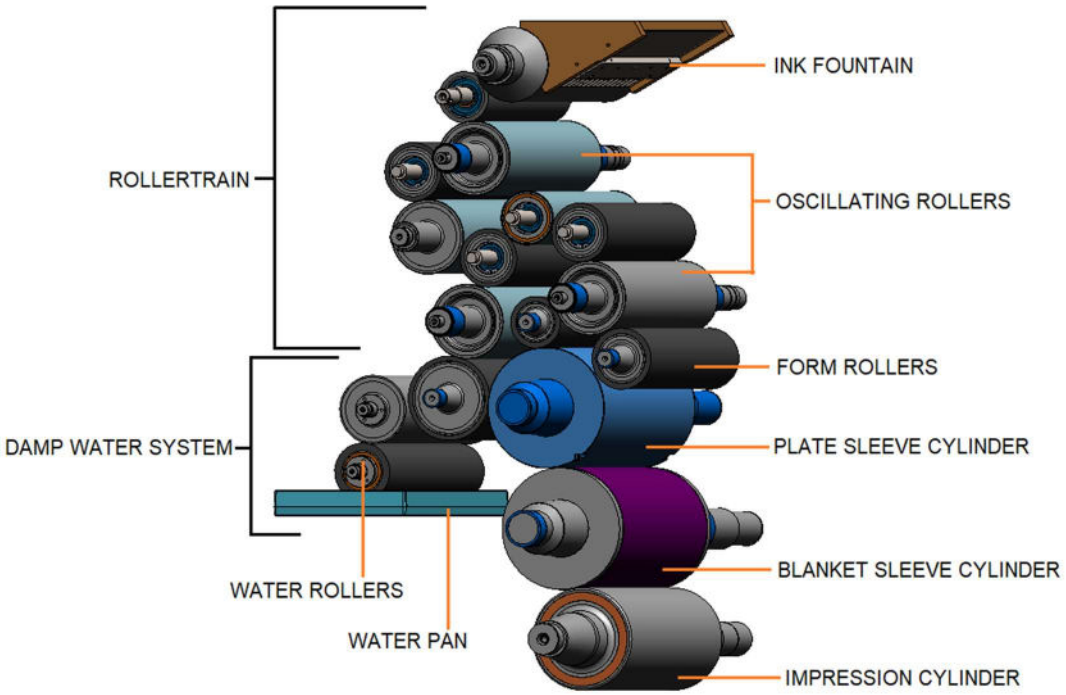

*Figure 1 Rollertrain and printing cylinders of a **DG-AUXO** web offset print unit*

The dampening water, sometimes referred to as ‘fountain solution’ because of its composition, plays an important role in the offset printing process. It builds a tiny layer on the hydrophilic non-image areas of the plate which ensures that the ink only is attracted to the polymer image areas of the plate and not to the non-image areas. Good water conditioning and accurate water feeding result in sharp and high-quality printing.

The printing blanket on the blanket cylinder acts as a transfer medium for the ink, from the offset plate to the substrate. The relatively soft and compressible printing blanket provides optimal rolling conditions between the printing cylinders and prevents early damage to the image areas on the offset plate. Its capability to slightly deform under pressure while maintaining quality transfer of the ink dots, allows good ink transfer even on paper and cardboard types that have a rougher and uneven surface.

Modern web offset presses have the ability to handle a wide range of different substrates, varying from various cardboard qualities and paper stocks to a wide range of plastic films. The previous combined with fast and comfortable print length variability make web offset the technology of choice for a large variety of printing applications. Web offset is overall and in general the most efficient, sustainable and versatile printing process for high-quality printing of short, medium and medium-long print runs.

2. Offset printing with variable repeat sleeve cylinders

Traditionally, web offset presses have a fixed print repeat length, which is appropriate for most heat-set, cold-set, and other commercial printing applications. However, when it comes to printing flexible packaging and labels, where numerous different printing and cut-off lengths are common, a web offset press with fixed-size cylinders and a fixed print length is not suitable.

For decades the market of flexible packaging and labels has been dominated by flexo and rotogravure printing because for both technologies the exchangeability of individual printing cylinders for cylinders with a different repeat length is standard. However, both technologies have significant drawbacks regarding time-to-market, energy consumption and process sustainability when compared to web offset.

It was already long time evident that web offset with energy curing could bring some decisive advantages to flexible packaging and label printing as soon as the hurdle of fixed print repeat length would have been resolved.

In fact, repeat length variability for web offset was already resolved for more than two decades, but the solution, exchangeable steel cassettes comprising of gear-driven steel cylinders between robust frames, was very heavy and expensive and not suited for individual servo drive control of each of the printing cylinders.

Figure 2 Steel cassette with printing cylinders of a DG-Vision web offset press

Although cassettes offer variable print repeat length, the high costs of steel cassettes are an economic barrier to invest in a considerable amount of different formats. Print houses operating the cassettes-based DG-Vision press series, typically have maximum 2 or 3 different repeat lengths in stock.

As around the year 2000 the potential of web offset printing in flexible packaging became fully clear, DG press engineers, at that time working for Drent Graphic Machines, developed an advanced solution, the Variable Sleeve Offset Printing technology, abbreviated as VSOP. With the VSOP technology printers and converters overcome the limitation of fixed repeat formats. This innovative technology enables easy and efficient change of print sleeve cylinders of different sizes without the need to remove heavy and expensive printing cassettes.

Figure 3 Easy sleeve cylinder exchange. Centre, manually and right with use of ProArm tool

The sleeve cylinder approach is not only quick and simple, it is also cost-effective, in particular for printing operations where print lengths change frequently between jobs. Plates and blankets are in the pre-press and make-ready stage already pre-mounted on the sleeves allowing an immediate continuation of the print production after a sleeve exchange.

In summary, the innovative variable sleeve offset printing technology makes it possible to use the sustainability, quality and efficiency benefits of web offset for printing flexible packaging and labels. The ***DG-AUXO*** web offset press series from DG press is the further improved 3rd generation of VSOP technology-based presses on the market.

3. Markets and Products served by DG press' web offset series

The portfolio of DG press actually contains two printing press model series. First the DG-Vision, a very successful and long-time running machine for various markets but especially in security printing and pharma. Second, the ***DG-AUXO***, a state-of-art technically advanced and extremely versatile machine, dedicated to flexible materials but suitable for many markets including cardboard packaging.

DG-Vision

The DG-Vision was originally developed in 1995. Over the years it has been improved mechanically and electronically to the highly efficient and versatile printing platform that it is today! The DG-Vision was the first fully servo-driven web offset press in its segment. Equipped with exchangeable steel cylinder cartridges the DG-Vision facilitates print production for a range of different print repeat lengths. The servo drive technology supports the DG-Vision's enhanced modular design and almost limitless configuration possibilities.

From the many available modules, the more common DG-Vision press configurations typically consist of wet- and dry-offset units, letterpress units, flexo units, rotogravure units, screen printing units, numbering units, digital printing modules, die-cutting units, cross and long perforation units, pin-feed and file-holder perforation units, matrix rewinders, sheeters, sheet-stackers, high-pile delivery and zig-zag folders.

This versatility of configurations makes the DG-Vision the ideal choice for a large number of market segments and products. Nowadays a wide range of products are printed on DG-Vision presses all over the world, including self-adhesive labels and a variety of plastic films. The steel printing cylinders make the DG-Vision particularly suitable for printing on paper and cardboard.

Available ink drying technologies are UV and LED-UV curing, conventional drying by oxidation, IR-drying, and hot-air drying tunnels for flexo and rotogravure units.

Figure 4 DG-Vision 520 web offset press, free configurable for a wide range of markets

Key markets served by DG-Vision are:

- Security printing of tickets, tax labels, passport inlays, stamps, voting ballots,
- Label printing of self-adhesive labels, wrap around labels, paper wet-glue labels
- Commercial printing of brochures and leaflets, calendars,
- Business forms printing delivery as A3, A4 or A5 sheets, different repeat zig-zag forms
- Cardboard printing of small boxes and cardboard tickets

The DG-Vision is available in two widths, 520 mm and 670 mm, and can operate at speeds up to 400 m/min.

DG-AUXO

The ***DG-AUXO*** is the most versatile web offset press on the market today. The ***DG-AUXO*** was developed by DG press' engineering team with over 20 years of experience in variable-size web offset press design, dating back to 2003 when the first VSOP press was developed and introduced in the market.

*Figure 5 Various examples of markets and products served with **DG-AUXO** and*

Since the launch of the VSOP technology web offset has entered and gained its place in new markets like flexible packaging and labels. The ***DG-AUXO*** represents the third generation of variable size offset presses, and distinguishes itself from other variable-size web offset presses by its highly modular design and complete freedom of configuration, offering unparalleled versatility.

Similar to its older brother, the DG-Vision, the ***DG-AUXO*** can also be equipped with a wide variety of different modules. Among the numerous modules available to build the most suitable ***DG-AUXO*** press configuration are wet- and dry-offset units, letterpress units, flexo units, rotogravure units, screen printing units, numbering units, digital printing modules, die-cutting units, cross and long perforation units, pin-feed and file-holder perforation units, matrix rewinders, sheeters, sheet-stackers, high-pile delivery and zig-zag folders.

The variable sleeve technology and easily exchangeable sleeve cylinders make the ***DG-AUXO*** series perfectly suited for markets with little product standardization and a large variety of product sizes, as is the case for flexible packaging and labels.

Variable-size sleeves combined with the latest in servo drive and energy-curing technology make the ***DG-AUXO*** the best choice for the production of flexible packaging.

Originally dominated by flexo and rotogravure, flexible packaging printing is now at a tipping point to become drastically more sustainable by phasing out solvent-based and energy-consuming printing techniques by replacing them with sustainable variants based on energy curing systems, like UV and EB.

*Figure 6 The fully modular **DG-AUXO** web offset press series is freely configurable, providing the flexibility and versatility to produce almost any product on the market*

Key markets served by the ***DG-AUXO*** press series are flexible packaging printing for all kinds of pouches, pillow bags, HFFS and VFFS packaging films, and label printing of shrink sleeves, IML, wrap-around labels, self-adhesive labels, and also cardboard printing of cereal boxes, tobacco packaging, liquid cardboard packaging and the like.

The ***DG-AUXO*** is available in three different widths from 520 mm and 900 mm up to 1085 mm, and can operate at speeds up to 400 m/min.

4. Why consider investing in web offset over flexo and rotogravure?

Offset's high print quality is well known and not in dispute. Nevertheless, nowadays there are additional compelling arguments why printers and converters of flexible packaging should seriously consider web offset. Web offset is the most sustainable alternative for VOC, solvent-based and water-based printing technologies like flexo and rotogravure. Besides being highly sustainable web offset brings some notable cost advantages, especially in short-run operations.

Sustainability advantages

Environmental concerns are becoming more important and already started to define the agendas of governments and authorities in an effort to turn the tide.

In cooperation with film and paper manufacturers, packaging converters and brand owners launch numerous new packaging concepts in an effort to keep up with or stay ahead of the newest packaging regulations whilst trying to create a "green" image and win the customer's favour.

One trend is the move to mono materials in flexible packaging, providing better packaging recyclability. It is favourable among large brand owners and packaging converters. Co-extruded and pre-laminated film structures eliminate the need for post-print lamination, which is a huge sustainability advantage, while at the same time encouraging the use of surface printing including the growing use of first-down white and functional and aesthetic varnishes, facilitating easy de-inking without the need for delamination.

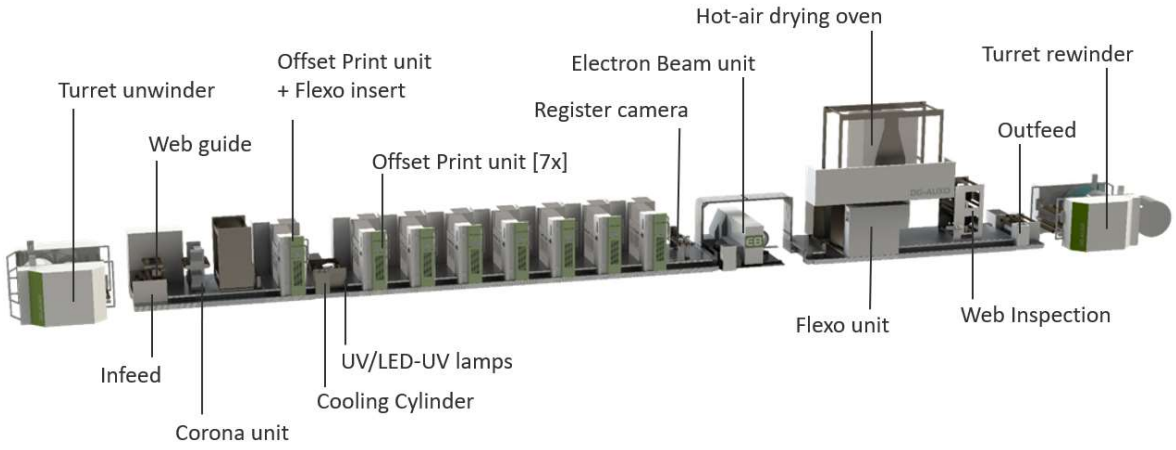

*Figure 7 **DG-AUXO** 900 web offset press configuration with an in-line flexo unit*

In flexible packaging printing the modular design of web offset printing presses holds the strongest cards, offering freedom of configuration to match the actual needs of modern packaging concepts. Hybrid web offset presses combine offset printing with energy curing and inline modules like digital print units for coding and serialization to flexo units for coatings and whites and rotogravure for cold seal to only name a few.

Solvent free ink

On the printing side, most flexo and rotogravure operations still do emit substantial quantities of harmful substances from solvent-based inks into the environment Even when free emittance is prevented by incineration or oxidation during production, huge volumes of fossil or renewable fuels are lost, resulting in a significant CO_2 footprint. These aspects are often dismissed as trifles and minor when compared to the weight of the total package, but therein lies the danger.

The inks used for web offset are energy curable and free from any solvents, in contrast to the inks used for flexo and rotogravure printing and, as a result, no afterburners nor oxidizers are required to reduce the solvents that are evaporated and trapped in the hot air. Energy curing prevents excessive CO_2 output and in a number of cases the need to supplement thermal oxidizers with natural gas.

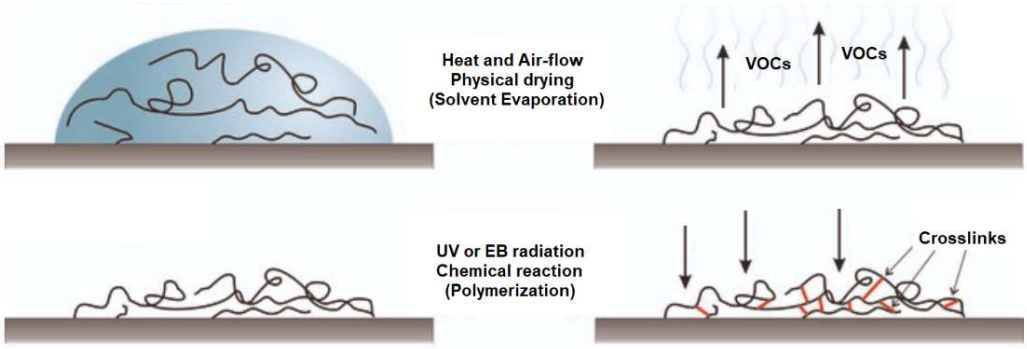

Figure 8 Top. Solvent evaporation by forced hot air from solvent-based ink.

Bottom. Polymerization of an energy-curable ink by radiation impact.

Cost-effectiveness

Web offset printing is more cost-effective as costs for print-ready aluminium offset plates and prepress are much lower than for example flexo polymer plates or copper engraved cylinders for rotogravure. This advantage is immediate and for every job. For smaller jobs and short-run lengths, this benefit is even more evident than for large jobs and longer runs.

Low starting costs per job are of significant and growing importance since the variety of tastes and flavours, pack sizes, and regional, seasonal, and promotional packages are increasing. The ever-changing European or national regulations regarding food safety, nutrition facts and instructions for EOL packaging handling have resulted in a significant reduction in the volume of individual print orders over the past decades.

The challenge for converters lies in the fact that profits will increasingly have to come from shorter runs. Whilst running short runs, it is essential to avoid the high initial costs associated with flexo and rotogravure. Web offset sleeve technology is a game changer for short runs because the plates and blankets for the next job are readily mounted a job change on a web offset press is a matter of minutes.

Quality, Versatility and Flexibility

Web offset printing produces sharp, high-quality images and text combined with precise and accurate colour matching. Web offset can print combinations of solids and fine screens easily within one print unit, avoiding splitting up into two designs because of anilox limitations.

Web offset press configurations that can facilitate 7 fixed process colours, known as extended colour gamut (ECG), offer the next level of efficiency, reducing the need for spot colours and at the same time reducing time for colour changes and eliminating waste of inks and washing liquids. Additional offset print units are available for white and speciality inks providing security aspects for anti-counterfeiting and coding for deposit and refund programs on bottles and cans or for selecting and separating packaging for waste streams.

*Figure 9 **DG-AUXO** 900 with 7 print units for ECG printing*

Finally, web offset presses with sleeve cylinder technology are extremely versatile, as they can print on a wide variety of substrates, ranging from paper and cardboard, over plastic films and aluminium to sheet metal.

Offset Printing - How it works

1. How are offset printing plates imaged?

Offset printing plates consist of an aluminium carrier plate of approx. 0,30 mm with on top a tiny ink-accepting polymer layer with a thickness of approx. 1 µm. The polymer layer is light sensitive to UV laser (430 nm) or Thermal IR laser (830 nm).

Pre-press for offset printing is a highly automated and standardised process that most offset printing companies have in-house. It starts in the pre-press department with the original artwork from the customer. In prepress the image will be evaluated regarding colour and converted into a printable image based on the applicable colour profile from the press to ensure that the colours of the printed products will match the original colours as demanded by the customer. Overfill is applied where necessary and texts and barcodes are checked for completeness and correctness. Usually, a hard proof is printed on a calibrated plotter for validation and comparison at the press. Some brand owners still require such hard proof for approval.

Once the proof has been accepted by the customer, the prepress department will make the imposition, being the layout on the plate, with combinations and repetitions of the individual designs, place all the required print marks and eye marks, and make a printable pdf that is stored on the CTP file server.

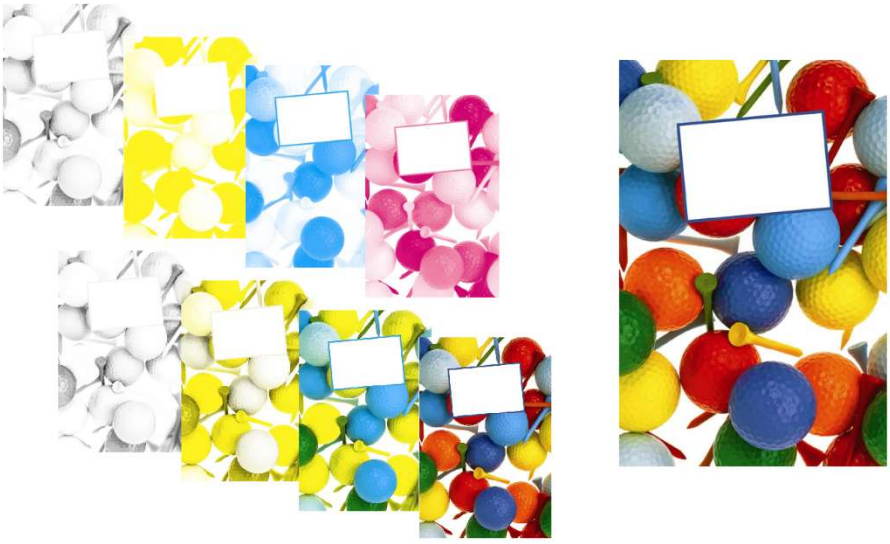

Figure 10 Colour separation of a 4-colour image into C, M, Y and K

The printable pdf file consists of individual layers, one for each colour. The individual layers or colours, pass through Raster Imagine Processing (RIP). From there, the individual ripped files are sent to the CTP to be imaged on the plate.

Depending if the plate chemistry is positive or negative working, the laser in the CTP image setter makes the images on the printing plates using a photomechanical or photochemical process. After the exposure step, the image on the plate is developed in the plate processor, where all the polymers from the non-image area are removed. The remains of the original, ink-accepting, light-sensitive coating create the image.

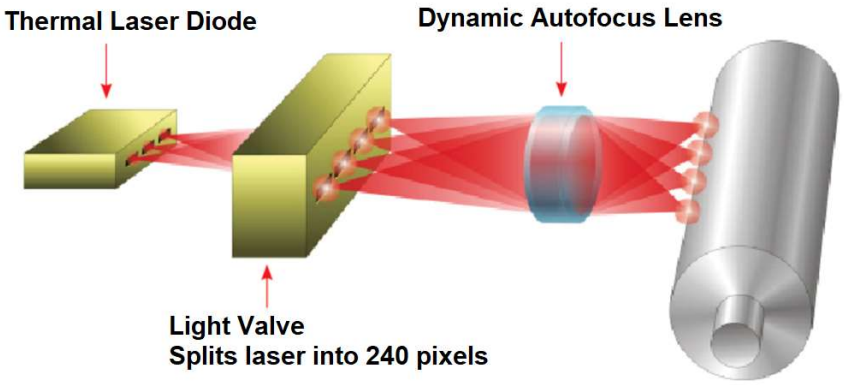

Figure 11 Principle of a laser imager for offset plates in a CTP system

An offset plate is not only up to ten times more affordable than a flexo cliche it can also be produced within a few minutes! This makes offset technology ideal for short-run work that requires rapid turnaround times.

2. What is the purpose of the printing blanket in web offset?

The main purpose of a printing blanket is to transfer the ink from the offset plate to the substrate. All offset printing presses make use of a printing blanket around the blanket cylinder. A printing blanket is a layered laminate of multiple fabric layers, a compressible layer in the core between the fabrics and an elastomer top or cover layer, typically being an NBR or EPDM rubber compound.

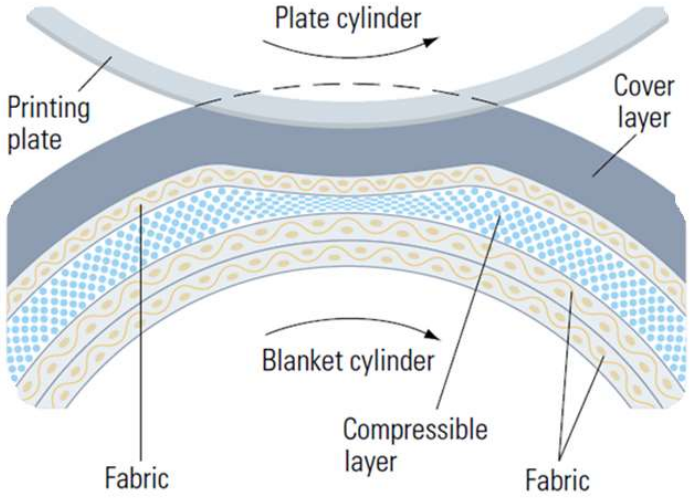

Figure 12 Cross section of a printing blanket showing all the functional layers

The printing blanket gives offset a decisive advantage over flexo and gravure printing when printing substrates with a rough or uneven surface. The combination of flexibility and compressibility allows the blanket to adapt to variations in the surface of the substrate and little run-out failures of the printing cylinders. At the same time, the soft and compressible blanket prevents excessive wear of the image on the plate.

The double ink transfer step, from plate to blanket and from blanket to the substrate, has as a disadvantage some extra dot gain, or TVI (Tone Value Increase), but that aspect is taken care of in prepress by applying compensation for the dot gain.

Overall, the blanket plays a crucial role in the offset printing process, ensuring that the ink is transferred smoothly and consistently from the plate to the substrate, resulting in a high-quality print.

3. Non-printing gap in web offset printing explained

On offset plates, the image starts near the head of the plate and ends just before the tail of the plate. Therefore printed images in offset are non-continuous.

When an offset plate is mounted onto a plate cylinder, there is a small area without an image. This space without an image cannot transfer ink and therefore causes a non-printable area, known as the gap. On web offset presses with sleeve cylinder technology, the non-printable area is approx. 2 to 2,5 mm wide.

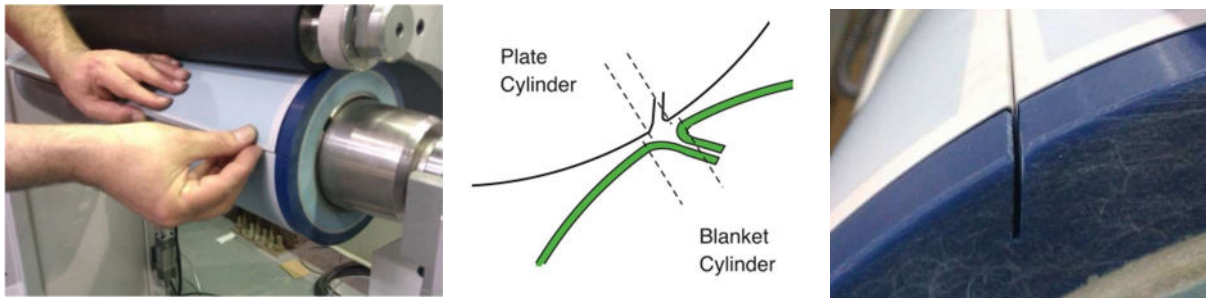

Figure 13 Left: Plate mounting Right: Size and position of plate gap and blanket gap

Typically, the non-printing gap off the plate is approximately 1,5 to 1,7 mm. The gap of the printing blanket is slightly wider, 2 to 2,5 mm, and symmetrically centred in relation to the plate gap to prevent the transfer from ink on the plate bends to the substrate.

The non-printing zone, or gap, is not unique to offset printing. The same applies to flexo plates, where the plates are applied onto a printing cylinder the non-printable area between the head and the tail of a flexo plate is approximately 1,5 mm or more.

4. How to control colours on a web offset press?

One of the main advantages of offset printing over other printing technologies is the possibility to apply colour improvements during the run.

Ink feeding on an offset press is set and controlled from an ink fountain and an ink fountain roller. The ink fountain is divided into multiple individual adjustable zones over the width of the press. Each zone has its own ink key, a digitally adjustable and highly accurate mechanism to set and control the amount of ink that is transferred from the speed-controlled ink fountain roller into the roller train.

In standard situations, the speed of the ink fountain roller follows the speed of the roller train according to a pre-programmed ratio or curve. However, if required, the speed can be adjusted on individual occasions, or by modifying the curve over a certain speed range.

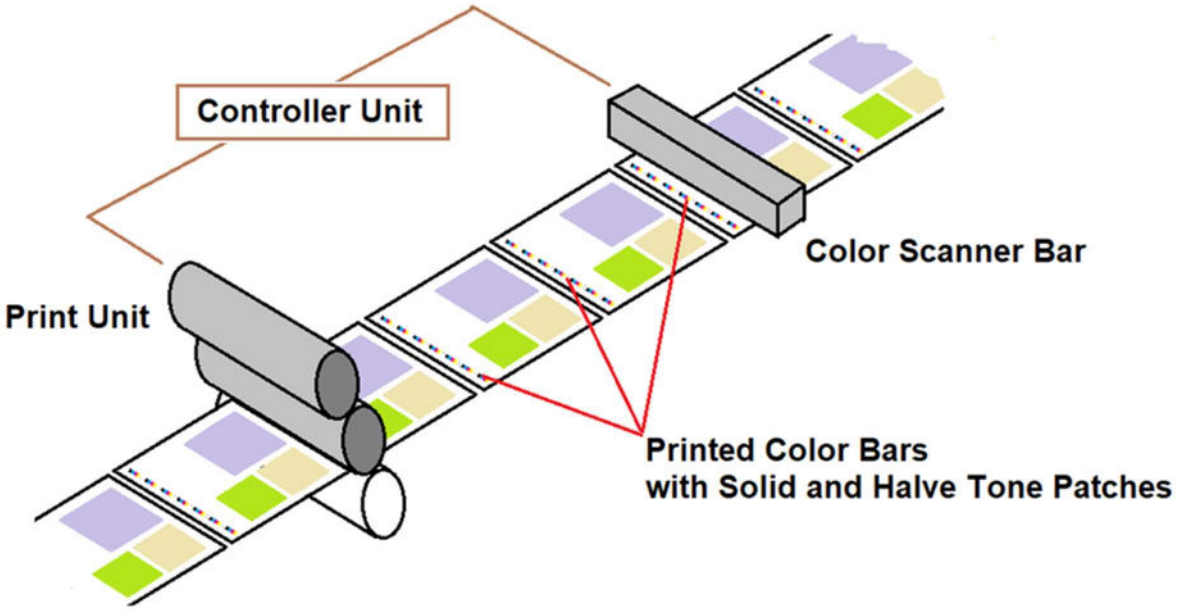

Figure 14 Automatic Closed Loop Colour Control for Optimal Colour Consistency

This freedom to influence the ink feeding locally facilitates also the possibility of closed-loop colour control, a feature that supports colour consistency over long runs. With closed-loop colour control, the density of the printed colours is measured directly after the ink is cured and dry. Depending on whether a deviation is found, the positions of the ink keys are corrected in zones where the measured values are outside a set tolerance. Measuring and correcting is a continuous process throughout the print run.

To start up a job with all the ink keys already in, or at least close to, their optimal opening positions modern web offset presses are equipped with an ink key pre-setting program called CIP3, or the newest version CIP4.

5. CIP-3/4 briefly explained

At the start of a new job, it is important to arrive at the correct ink density as soon as possible, providing just the right amount of ink into the roller train to minimize set-up waste and time waste. The automation system that provides the required data to optimize correct ink feeding from the start is called CIP3, and its successor is CIP4. CIP3 and CIP4 are two standards used in the printing and converting industry to transfer job-specific data throughout the production process.

CIP3 stands for "International Cooperation for Integration of Processes in Pre-press, Press and Post-press" and these standards are designed to facilitate the correct exchange of job information, including colour reproduction information between different software and hardware systems in the printing and converting workflow.

CIP3 utilizes Print Production Format files (.ppf) which is a long-time existing file standard for exchanging job and colour data between prepress, press and post-press systems. It enables fast and accurate pre-setting of the colour reproduction in the printing press.

CIP4, being the successor of CIP3, utilizes the newer Job Definition Format files (.jdf). CIP4 is the improved and extended version of the standard that builds on the functionality of CIP3 and extends it to cover the entire printing and converting production workflow, including prepress, press, and post-press operations.

The JDF files facilitate the communication of all job instructions for pre-press, press and post-press, including colour information, all in one file, to facilitate that the final product meets the desired result. This information is vital for colour management and includes details related to colour separations, ink coverage, job dimensions, and more, providing data for accurate and consistent colour reproduction.

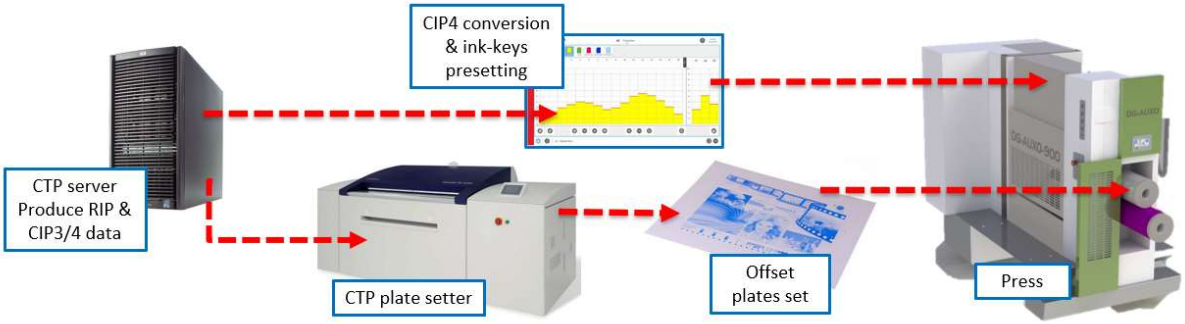

Figure 15 CTP-server data processing, RIP data for CTP and CIP data for ink-key pre-setting

The CIP3/4 data for ink key pre-setting is generated in the CTP server after colour separation and Raster Image Processor (RIP). The CIP data is uploaded from the CTP server to the ink keys controller at the press control desk. The provided ink coverage data is used to calculate the pre-set values for the individual ink keys. The more accurate the settings, the faster the job arrives at its exact colour, and the lower the setup waste.

6. How does Extended Color Gamut contribute to Web Offset printing?

In packaging and label printing the use of CMYK plus additional spot colours is very common, although the use of spot colours has several disadvantages, like high ink waste and time-consuming colour changes between jobs. An efficient alternative is to switch to Extended Color Gamut printing (ECG). ECG is based on the use of 7 process colours in fixed positions on the printing press, instead of the 4 standard process colours CMYK plus various spot colours. ECG offers several clear and convincing advantages regarding time and materials savings.

- Significant extension of the colour gamut in comparison to CMYK.
- Reduction of PMS colour inks.
- ECG can reproduce roughly 82% of PMS gamut within $\Delta E2000 \leq 2$.
- Time-saving in job changeover.
- No washing nor re-colouring of the printing units.
- Savings on ink consumption.
- Less ink waste, and less consumption of washing fluids.
- Simple logistics, simple stock management and less storage space.
- No colour mixing, no mixing errors, no quantity failures nor ink surplus.

The concept and benefits of ECG are not new at all. ECG has some well-known predecessors, such as Hexachrome and Opaltone. However, both never became quite as successful because of various reasons of which costs for license fees and the use of a non-standard colour set are two. However, in order to benefit from ECG it requires an accurate and stable colour-to-colour register on press and a robust level of standardization in pre-press and on-press procedures, including calibration and maintenance of printing and pre-press equipment

Besides web offset, other printing technologies also benefit from the use of ECG. Offset, however, has some specific qualities, like good reproduction of the finest screens, the broadest choice of AM, FM and XM screen types and a stable and accurate colour-to-colour register that makes offset ideally suited when it comes to ECG performance and execution.

Not all spot colours can be reproduced easily and accurately with ECG. Based on the availability of accurate colour profiles for a certain combination of consumables modern colour conversion software can calculate and predict which spot colours can be reproduced with ECG or, if not exact, how much the ΔE off-value will be upfront. Depending on the ΔE value that is acceptable for the customer the use of one or more spot colours might still be required.

*Figure 16 **DG-AUXO** 900 web offset press equipped with 7 units for ECG*

7. Which Ink systems are suitable for Web Offset printing

The inks that are used for web-offset printing can be divided into two groups, oxidizable inks based on mineral oils and energy-curable inks based on polymer chemistry. There is a third group, the heat-set inks based on volatile oils, but as that technology is only used for high-speed printing on paper for instance to produce magazines it is not of relevance in the context of this guide.

Oxidizable, mineral oil-based inks are the long-time workhorse in web offset, and in offset printing in general. These inks require absorbent substrates like paper and cardboard. They do not function on non-absorbent substrates as they require partial absorbance by the surface of the substrate and require some time to dry by oxidation and partial evaporation. When only printing on absorbent substrates mineral oil-based inks will be suitable. Additional IR-drying (heat) on the press facilitates printing at higher speeds without the risk of ink set-off.

Energy-curable offset inks dry by crosslinking polymerization. These inks do not need to be absorbed by the substrate and are therefore suitable for printing flexible packaging. Energy-curable offset inks do not contain any ingredients that evaporate. The ink turns from a liquid to a completely solid state in a fraction of a second. There are three main technologies of energy curing used for the polymerization, and thus curing, for these types of inks.

Ultra Violet (UV) curing starts the polymerization of the ink by a broad spectrum of UV radiation emitted from a Mercury lamp. Certain wavelengths in the UV spectrum activate a blend of photoinitiators in the ink. The photoinitiators break down into free radicals, initiating a free radical polymerization chain reaction.

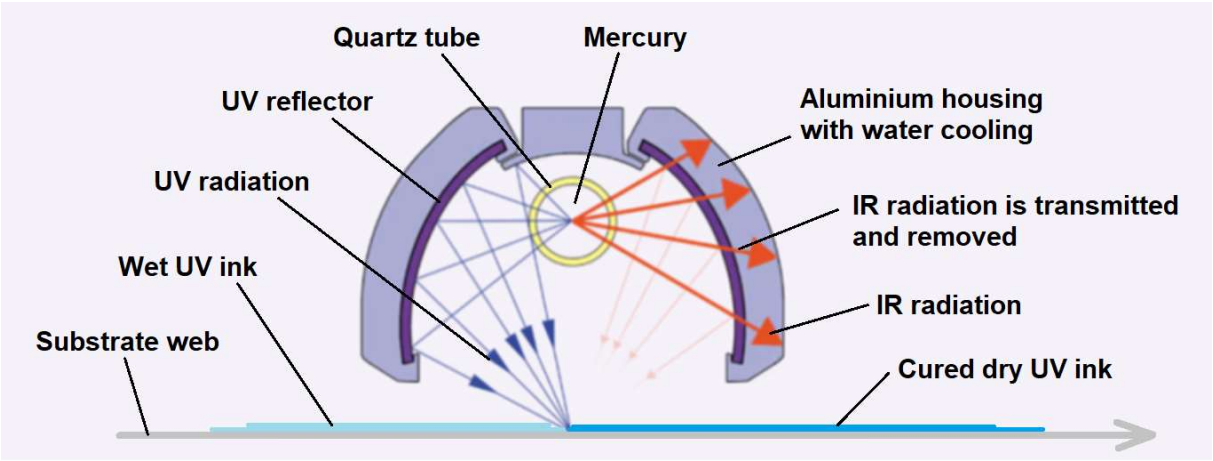

Figure 17 Cross section of a Mercury UV radiation lamp

LED-UV generates UV radiation at specific narrow wavelengths, for example, 385 and 395 nm. The curing mechanism works identically to conventional Mercury UV, only the photoinitiators in the ink are specially selected to match the specific wavelengths emitted by the LED-UV lamps. LED-UV has several advantages of which low energy consumption is the most significant at the moment.

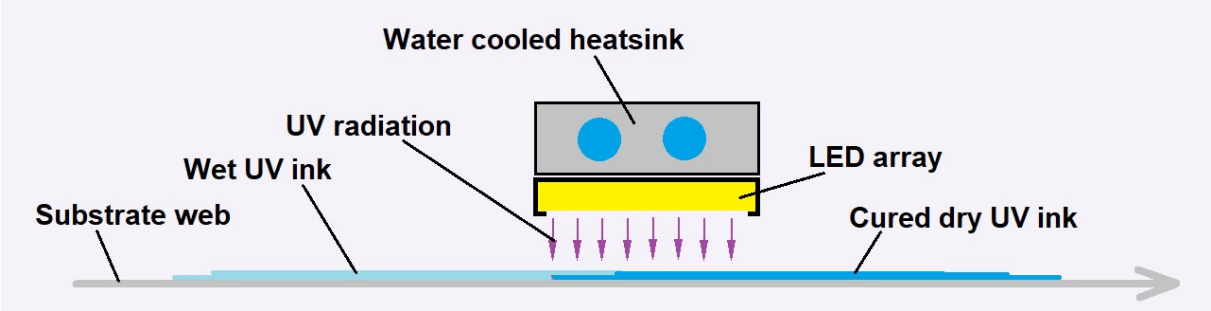

Figure 18 Cross section of the composition of a water-cooled LED-UV array

Electron Beam (EB) curing starts the polymerization reaction in the ink by firing high-energy electrons that penetrate the ink layer. When the electrons hit on the monomer and oligomer molecules in the ink they initiate a free radical polymerization reaction. EB curing radiation is very powerful and colourblind, meaning that the electron penetration is not hindered by any type of pigment, ensuring that all colours are equally efficiently cured.

EB can cure through thick ink layers including whites and varnishes. An EB curing unit is quite a big piece of equipment with a high-level investment. For these two reasons, EB units are only used as end curing units, never as intermediate curing solutions.

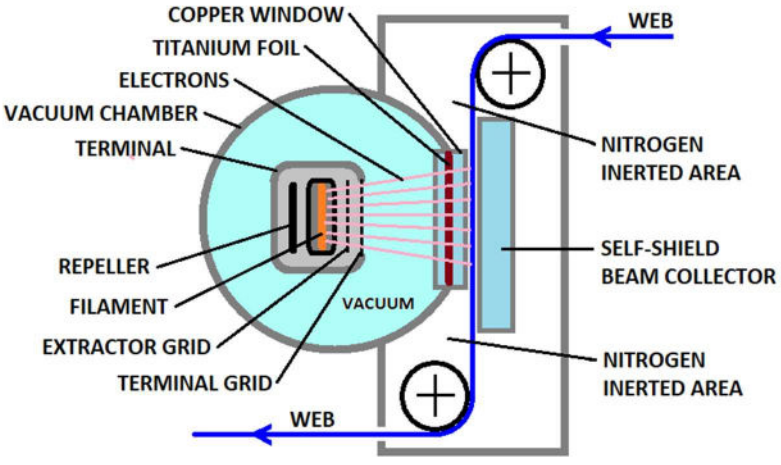

Figure 19 Cross section of an Electron Beam, electrons emitting radiation device

The oxygen from the air has a negative impact on the curing process. When the highly energized electrons hit on oxygen molecules ozone is formed which is unhealthy for the operators and increases the risk of corrosion on nearby machine parts. As a second effect, oxygen molecules connect to free radicals in that way inhibiting the polymerization reaction.

To prevent the formation of ozone and to prevent inhibition of the polymerization reaction the oxygen must be removed from the reaction area. By purging the area with an inert gas, typically nitrogen, the air containing oxygen is replaced by an inert nitrogen atmosphere.

8. How long does a job changeover take on a web-offset press?

Changing from one job to another on a web-offset press with sleeve cylinder technology is easy and fast. The paste inks are easy to remove from the ink fountains and the rollertrain in each print unit has an automatic functioning and free programmable washing system. The total quantity of ink residue per print unit is low and the required washing liquid is only a few cubic centimetres per cycle.

The total time required for a job change depends on the configuration of the press and the complexity of sequential jobs. The exact time of a job change can only be calculated when both previous aspects, press configuration and complexity of the jobs, are known. The total time for a changeover depends mainly on the following aspects:

- Number of offset plates that need to be exchanged
    - Change of plate sleeves and their corresponding blanket sleeves, for each colour required in the new job.
    - Offset plates and printing blankets are already pre-mounted on the sleeve cylinders, beforehand.
- Change of colours in offset print decks
    - When running 4 process colours (CMYK) plus some Pantone spot colours, exchanging PMS colours for other PMS colours might be necessary. This requires that the residue ink is removed from the ink fountain and that the roller train is washed- before the new colour can be put in the print unit.
    - When running 7 process colours (CMYK+OGV), known as Extended Colour Gamut, there is less or no need to change ink colours in the print units as most of the required spot colours are reproduced based on the 7 ECG colours in the press. This is extremely fast, easy, efficient and implies significant cost savings.
- Changing the substrate to print on for the new job.
    - The dedicated trolley for transportation and lifting of the substrate reels makes reel changing a safe and easy task.
    - When the press is equipped with an automatic unwinder, the reel with the new substrate can already be loaded while the previous job is still running in the press. This makes the time between jobs even shorter.
- Job data loading and pre-setting
    - Pre-setting of all job-related parameters is fully automated. Once the job data has been uploaded and approved by the operator, the various mechanical adjustments will find automatically their exact positions.

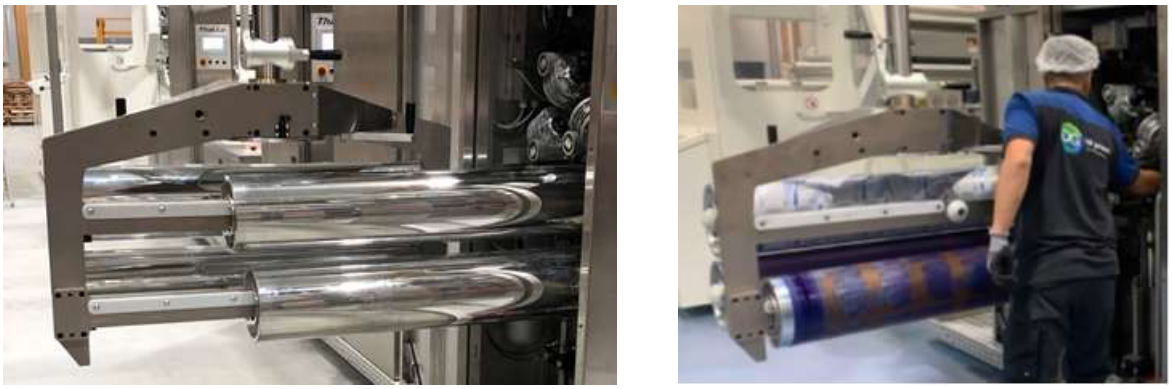

*Figure 20 **DG-AUXO**'s ProArm tool for easy and safe handling of large-size sleeve cylinders*

Changing the sleeve cylinders on a mid-web sleeve offset press like a ***DG-AUXO*** 520 or even on a ***DG-AUXO*** 900 can be done manually in a safe and easy way. However, sleeve cylinders for wider web-offset presses, like, for example, the ***DG-AUXO*** 1085 series, can be much heavier and are therefore unsafe to be handled manually.

ISO 11228-1, an international standard on manual handling of loads, states 25 kg as a maximum weight for the general working population, but the exact maximum allowed weight can be far less depending on lifting frequency and duration during a working day. It is for this reason that DG press developed the ProArm tool that makes sleeve changes on a ***DG-AUXO*** 1085 comfortable, fast and safe.

9. Web offset, productivity and efficiency

The productivity of a web offset press obviously depends on a number of aspects. Largely depending on the run lengths of the jobs, efficiency and speed during print production are important, but fast and efficient changeover from one job to another as well. For optimal performance, both aspects rely on the quality of the preparations done during prepress and make-ready.

Pre-press and make-ready

Consequent use of industry standards and procedures is key in prepress, job make-ready and during printing. It is the basis for efficient and economic printing operations. All devices involved in the process, including the press itself, CTP equipment, plotters and measuring tools must be well maintained and calibrated in order to make printing predictable and reproducible.

The process starts with obtaining the relevant colour profiles from quality fingerprints made with a standardized set of consumables, like inks, screens and substrates, and printing conditions.
Based on a colour profile that matches the job, the colours from the original artwork are converted into the colour set that is used on the press. That can be a standard and straightforward 4colour process (CMYK) eventually complemented with additional spot colours, or a highly efficient extended colour gamut, based on 7 fixed process colours (CMYK+OGV).

To produce a set of imaged plates is, with modern CTP, only a matter of minutes. A set of 7 mid-web-sized plates takes less than 10 minutes for imaging and processing. Modern plate bending devices with optical positioning provide exact and accurate bending of head and tail, securing easy mounting and perfect fit of the plates on the sleeve cylinders. Mounting an offset plate onto a sleeve cylinder takes less than one minute!

All the previously mentioned preparations are done outside the press without interfering in actual production runs.

Short change over time between jobs

The time required to change from one job to another on a web offset press with sleeve cylinder technology is the shortest among all traditional printing technologies, only beaten by digital printing technologies. However, once up and running the productivity of a web offset press easily outperforms that of a digital press.

The relatively lightweight printing sleeve cylinders of narrow and mid-web-sized web offset presses allow manual changing, offering fastness and the highest flexibility. Wider presses, over 900 mm in width, or sleeve cylinders with large diameters can be changed safely and comfortably with the help of a lifting and handling tool, like for example ***DG-AUXO`s*** ProArm (Fig. 17).

On a modern web offset press most adjustments for a new job are parametrized and job pre-setting is highly automated. For example, the nip-positions for rollers and cylinders are automatically set according to the thickness of the substrate and all ink keys are preset following CIP3/4 data input obtained from the designs on the offset plates.

More detailed information about efficient job changes on DG press' web offset presses with sleeve-cylinder technology is available in Chapter 8.

Efficient print production

Modern servo drive technology ensures that from the start of a new job, the individual colours are close-to-exact in register. At press start the dynamic register control moves each color rapidly in its final position. The servo drive technology assures that register positions are kept accurately even on film substrates, giving the automatic register system a lazy job for the rest of the run.

At the start of a job ink feeding typically requires some fine tuning as CIP3/4 ink-key presetting comes pretty close but not for all keys exactly spot on. Common practice is that with 2 sample pulls the "OK colour" is achieved and the production run can start.

Web videos and spectral line scanners provide valuable information to the press operator during a print run. The obtained data can be processed at different levels of automation, up to 100% failure detection. Giving the operators immediate and real-time access to the quality of the job and the possibility for corrective actions on variations in the printing as they occur. In this way maintaining a constant and high-quality output.

For print products that have the space and possibility to integrate a colour bar with individual patches the use of a closed-loop colour control system is beneficial as it automatically compensates for the drift of ink key positions due to slight temperature variations.

Presses equipped with turret un- and re-winders offer continuous and stable production of long runs without the need to stop and restart the press at each end of a substrate reel. Offering advantages like lower waste, less downtime and continuous print quality.

Hybrid printing

The achievable print production speed of a web offset press depends strongly on the various processes integrated into the configuration of the press. Straightforward web offset printing with energy curing, in combination with flexo or rotogravure white or varnish, allows print production at the maximum speed of the press.

Integration of other printing processes can hamper and reduce the achievable print production speed as many printing processes cannot perform at the high speed of a web offset press. Examples are digital printing units, roto-screen printing units and the application of water-based coatings, as the last one requires longer dwell time in hot-air drying tunnels to ensure a sufficient dry coating.

The impact of ink systems

The previous example shows already that type and capacity of the ink curing or drying process is an aspect that has a direct influence on the achievable printing speed.

Conventional mineral oil-based inks can be printed at speeds up to 150 m/min. Substrate characteristics are important as more absorbent substrates provide better conditions for higher speeds than for example a gloss-coated paper. Higher speeds are feasible but require support from drying technologies like infrared, hot air or the use of anti-set-off spray powder in the case of sheet-fed presses.

Mercury UV

The achievable printing speeds with conventional Mercury-based UV curing depend a lot on the total installed UV lamp power, lamp efficiency and on reactivity of the ink formulations. Low-power UV systems with standard UV inks allow printing speeds up to 200 m/min. However, UV systems with more lamps, higher efficiency and inks with enhanced reactivity easily arrive at speeds of 300 m/min and more.

LED-UV

LED-UV is gaining popularity mainly because of its lower consumption of energy. LED-UV inks and curing systems for non-FCM (Food Contact Materials) applications can perform up to 300 m/min and higher when correctly designed for the intended application. For FCM applications, where the inks are based on a different set of low migration photoinitiators, the typical production speeds lay in the range between 120 and 200 m/min.

EB

Electron Beam curing is extremely powerful and colour-blind and therefore able to cure all energy-curable ink layers at press speeds up to 400 m/min. The absence of photoinitiators in EB ink formulations is a compelling advantage for printing food packaging.

Another positive impact of energy-curable inks on the packaging production process does not emerge during print production but during post-processing and finishing of the printed products.
Energy-curable inks, both EB and UV, have a clear advantage over solvent-based and water-based inks that they are immediately dry after printing and ready for further processing or transport. No waiting time is required for solvent retention.

Hot Air drying

Hot-air drying systems and coatings can keep up with electron beam curing as long as the length of the drying tunnels and the volume of the airflow and the temperature of the drying air is calculated and installed to match the overall speed requirements.

Substrate

The final aspect that has a significant impact on the max achievable stable print production speed is the characteristic of the substrate to be printed. For quality printing and exact print length, a certain web tension must be maintained throughout the print job.

The combination of web width and thickness and E-modulus can provide an indication if a film is suitable to be printed with all colours exactly in register and at the same time achieve and maintain the required print length.

Stretchable films, like LDPE, can be more challenging to print correctly than more rigid films like PET and BOPP. The web offset presses from DG press are equipped with state of art servo drive technology combined with advanced web tension control, ensuring high-quality colour-to-colour registration and exact print length. This outstanding technical performance maximizes the range of printable substrates.

Besides web tension control, another impact on the web comes from the printing ink. Web offset inks are paste by character and some of these inks can have a relatively high tack (pulling force) on the web when releasing from the printing blanket directly after the nip. This in combination with the design to be printed can introduce local differences in web tension resulting in wrinkles and locale register differences. Continuous ink temperature control and stable ink-water balance are important parameters to secure that ink tack and viscosity stay within the correct range of operation.

An unlucky combination of a stretchable substrate with a high tack ink and high ink and a design with high ink coverage can have an impact on the quality of the print. A limitation of the printing speed to a more moderate level will reduce the released forces and thus their impact on print quality.

10. Future developments in Offset Printing

Although web offset printing is still the favourable printing process for printing applications like magazines, newspapers, books, brochures, catalogues and direct mail it is losing terrain to digital and online alternatives in the mentioned fields.

In flexible packaging and labels, the situation is different as that is the field where web offset still has an enormous growth potential due to its energy efficiency and sustainability advantages over solvent-based and water-based printing technologies.

Because of recent advancements in variable sleeve offset technology and energy curing technologies for inks, web offset printing has become the more cost-effective option for flexible packaging, gaining momentum as the most sustainable alternative when compared to solvent and water-based printing technologies.

Like many other technologies web offset will benefit from further digitalization in prepress and printing operations. Fast and accurate data transfer will facilitate efficient job set-up and contribute to waste reduction. Overall it will improve print quality and consistency, speed and flexibility.

One technology supported by powerful and modern digitalization is Extended Colour Gamut. ECG has several benefits over the use of spot colours. The benefits of ECG are best utilized by offset as it is the technology that can print the lightest screens and thus the widest range of screens.

Figure 21 ***DG-AUXO*** *900 Hybrid press configuration with multiple printing processes in-line*

Web offset with variable sleeve technology is transforming to become the main platform for hybrid printing. An inline web offset press with its servo drives and control structure is the ideal platform to integrate various other printing and coating technologies including digital printing, flexo, rotogravure, and hot- and cold-foil printing. Examples of possible applications are deinking primers, moisture, grease and oxygen barrier coatings and heat-sealable coatings.

Conventional printing images will be expanded with new technologies providing augmented reality and access to online variable data, which will allow for an enhanced customer experience for example instructions for correct product handling and safety and personalisation of printed materials.

Patterns and codes printed with inks invisible to the human eye will provide easy recognition and selection of packaging materials in automated recycling lines, facilitating optimal recycling of packaging materials. In a growing number of cases, security elements will be integrated into flexible packaging and label products to secure food product integrity and origin and to prevent counterfeiting.

Printed security features and features for the detection and selection of products often require the use of specialty inks. This requires additional print units that are fit to apply the specialty inks in the correct way. Examples are the commonly known German “Pfand” logo with its associated ink and UV-fluorescence inks, anti-copy fluorescence inks, IR-visible and invisible inks, thermochromic inks and magnetic inks.

Figure 22 The German “Pfand” logo printed with specialty ink

Finally, the capabilities of offset printing are likely to further expand including a wider range of substrates or non-traditional substrates. Already the use of a compressible printing blanket makes offset the technology of choice for substrates with rough or uneven surfaces like uncoated papers, cardboard and non-woven substrates.

Annex 1 – Abbreviations

AM Analogue Modulated – Screen arrangement of the dots in a rectangular pattern.

CIP4 International Cooperation for Integration of Processes in Pre-press, Press and Post-press – CIP3, and the newer CIP4, are formats to communicate all aspects and parameters of a print job, including pre-press and post-print production steps, facilitating a high level of process automation. CIP3 communicates through .ppf (Print Production Format) files, whereas CIP4 communicates through the .jdf (Job Definition Format) files.

CMYK Cyan, Magenta, Yellow, Key – The standard colours in a four-colour process. Key stands for high contrast and detail which is typically provided by the black plate.

CTP Computer To Plate – Technology and device to apply an image on an offset plate directly by high-definition laser impact. The use of negative films as was typical in the past, and its associated flaws has been eliminated with the introduction of CTP.

ΔE Delta E – Distance between two colour locations in a 3-dimensional colour space. Commonly used to express the difference between a printed-measured colour and the intended target colour.

EB Electron Beam – Technology and installation that emits highly energized electrons which in turn start a polymerization reaction in an energy-curable ink or coating.

ECG Extended Color Gamut – Process printing existing of more than the standard 4 process colours cyan, magenta, yellow and black. Typically added colours are orange, green and violet bringing the total up to 7. ECG offers a far wider colour gamut (or colour space) reproduction.

EOL End Of Live - In and EOL scenario is described what will happen with the packaging after it has been used. This is especially important for SUP

FCM Food Contact Materials – Typically used for all packaging applications intended for primary food packaging applications.

FM Frequency Modulated – Screen arrangement appearing in a random way, although created by mathematical algorithms.

FMCG Fast Moving Consumer Goods – All kinds of products used in daily life that sell quickly at relatively low cost. FMCGs have a short shelf life because of high consumer demand (e.g., soft drinks and confections) or because they are perishable (e.g., meat, dairy products, and baked goods).

FD First Down – As is used in FD-white, indicating that the white is printed in the first position before all the other colours. Typical when surface printing on transparent film or on metalized film.

GHG Green House Gasses - A greenhouse gas is a gas that absorbs and emits radiant energy within the thermal infrared range, causing the greenhouse effect. The primary greenhouse gases in Earth's atmosphere are water vapour (H2O), carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and ozone (O3).

HFFS Horizontal Form Fill Seal – Type of packaging process and machine where the packaging is made and filled in a horizontal manner. Typically used for candy bars, certain types of ice creams and trays with cookies.

IML In Mould Label – Technology to apply a high-quality printed label inside a casting mould before closing and injection of the hot liquid thermoplastic plastic. Label, being the same type of plastic as the final rigid cup or container, provides excellent high-quality graphics, unmatched by any direct-to-cup printing process.

LCA Life Cycle Assessment – Method to determine the total ecological impact of a product over its entire life cycle. From cradle-to-cradle.

LD Last Down – As is used in LD-white, indicating that the white is printed in last position after all the other colours have been printed. Typical when reverse printing on transparent film for lamination.

LDPE Low-Density Polyethylene – Plastic used in flexible packaging with fair moisture barrier and perfect heat sealing properties.

OGV Orange, Geen and Violet – The three typical colours added to CMYK, to extend the standard 4-colour process to ECG printing.

PMS Pantone Matching System – System providing numerical organization of spot colours and basis for conversion to colour reproduction processes.

RIP Raster Image Processor – Part of the software inside the CTP server that takes care of the colour separations before plate imaging.

SB Solvent Based – Terminology used for inks that contain volatile organic compounds for viscosity regulation and fast drying.

SUP Single Use Packaging – Packaging that is only used once. Most food packaging is SUP, like for example candy bar wrappers and ice cream wrappers.

UV Ultra Violet – Ink curing technology and installation that emits UV radiation over a range of wavelengths. The UV radiation activates photoinitiators in a UV-ink or coating, creating free radicals that start a polymerization reaction of the UV-ink.

VFFS Vertical Form Fill Seal – Type of packaging machine where the pillow bags a shaped in a vertical way and the filling goods enter the bags vertically. Typically used for pasta, rice, sweets, powders, frozen vegetables etc.

VOC Volatile Organic Compounds - VOCs in inks are derived from fossil fuels. It are organic chemicals that have a high vapor pressure at room temperature.

WB Water Based - Terminology used for inks that contain mainly water as a vehicle, for viscosity regulation and drying by hot air.

XM X Modulated – Abbreviation for Cross Over screen types or Hybrid screening, referring to a combination of AM and FM screening.